Reconstruction of the Medial Patellofemoral Ligament for Recurrent Patellar Instability

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INTRODUCTION

Recurrent lateral patellar instability after traumatic patellar dislocation or subluxation is a commonly encountered problem. Fitzsimon et al. concluded that individuals with a history of recurrent patellar instability had seven times higher odds of subsequent instability episodes than first time dislocators. In recent years, the importance of the medial patellofemoral ligament (MPFL) as the primary soft-tissue restraint to lateral displacement of the patella has been corroborated by several authors. As an extension of these investigations, the MPFL has been established as the primary passive restraint to pathologic lateral displacement of the patella. Thus, by definition, the MPFL is always injured to some extent during traumatic lateral patellar dislocations. Repair or reconstruction of the MPFL is often recommended for patholaxity of the medial patellar stabilizers with the understanding that other medial tissues contribute (eg, medial patellofemoral). Although numerous procedures have been described for addressing insufficiency of the medial restraints (eg, reefing, advancements, and nonanatomic tendon transfer procedures), most were designed without the current anatomic and biomechanical knowledge of the MPFL and associated anatomic medial restraints. As a result, some of these earlier procedures have, at times, created the potential for abnormal forces and contact areas (leading to elevated stress) of the patellofemoral articulation. The current goal of patellofemoral surgery, in general, is to correct pathology without inflicting iatrogenic pathology by inadvertently increasing patellofemoral stress. Thus, in MPFL reconstruction, the goal is to recreate the restraint of the MPFL without creating abnormal biomechanics. To further emphasize this point, reconstruction is not an over-constraining procedure and does not seek to address static patellar position, nor is it indicated for primary problems of pain and/or arthritis.

The following technique describes an approach to the reconstruction of the MPFL using a free tendon graft. Proper selection of patellar and femoral attachment sites, anatomic and biomechanical testing (as opposed to isometric), length establishment (in distinction from tensioning), and fixation will be described. The graft is secured to the femoral attachment site with an interference fit bioabsorbable screw. Two variations for patellar attachment of the graft, with either suture anchor fixation or interference fit, will be detailed. This procedure may be performed in association with tibial tubercle realignment and/or cartilage restoration of the patellofemoral joint as per patient pathology and surgeon discretion.

PREOPERATIVE PLANNING

Physical Examination

A thorough extremity, knee, and patellofemoral specific physical examination is performed as detailed by Boden et al and Post. Specific to the MPFL, the extent of patellar medial/lateral displacement and patellar apprehension are documented. The patellar displacement examination is performed with the knee at approximately 20°-30° of flexion. The examiner palpates and holds the margins of the trochlea with the index finger and thumb. The trochlea is mentally divided into four quadrants. Using the index finger and thumb of the other hand, the medial and lateral margins of the patella are secured. A normally positioned patella will be central in the trochlea.

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at this degree of flexion. Any medial or lateral deviation from this starting point is noted.

The patella is then displaced medially and laterally while the trochlear quadrants of displacement (patellar glide) are recorded and compared to the contralateral knee. Three quadrants or greater of lateral patellar displacement suggest patholaxity (injury) to the MPFL. At this same degree of knee flexion, the patella lateral margin is assessed for mobility (tilt) in the axial plane, again gripping the patella with the index finger and thumb. The patella tilt noted initially should be reversible to neutral. Failure to reverse tilt is one indication of lateral compression and usually is associated with a decrease in medial glide (displacement) of the patella to ½ or less trochlear quadrant. A combination of increased lateral displacement past three trochlear quadrants (usually associated with marked apprehension) and clinical history of recurrent lateral patellar instability should be present to warrant MPFL repair or reconstruction.

The contralateral knee should be examined for comparison, but these independent guidelines are sometimes necessary as bilateral patellofemoral dysplasia and bilateral recurrent lateral patellar instability are common. It is important to use the Fulkerson test to rule out iatrogenic medial dislocations (post excessive lateral release), which can present with the patient reporting lateral dislocations by mistake (ie, a lateral dislocation, but in fact, the patella moves from an overly medial position laterally into the proper central trochlea position). The Fulkerson test is performed with the patient in the supine position. The examiner manually pushes the patella medially with the knee extended, which simulates the medial “drift” of the medial tracking patella. The examiner then abruptly flexes the knee and releases the patella. If the test is positive, the patient experiences the same feeling of instability, as this reproduces the abrupt relocation of the patella into the trochlea from its medial position in extension.

**Preoperative Imaging**

Three standard radiographs (anteroposterior, lateral, and low flexion angle axial [Merchant]), in conjunction with a thorough physical examination, usually are sufficient to plan MPFL surgery. Occasionally, stress radiography can help substantiate the clinical medial and lateral patellar displacement. True lateral radiographic views are useful for classification of trochlear anatomy/dysplasia and to document patellar infera or alta. Note that the radiographs are used in an accessory manner, ie, the radiographs help with determining bony injury, patellofemoral dysplasia, and patellar height, but the decision for MPFL reconstruction is based on the patholaxity of the MPFL. Magnetic resonance imaging (MRI) and computed tomography tracking studies may in certain instances contribute to planning information, especially in assessing tibial tubercle to trochlear groove distance (TT-TG measurement), tilt, and MRI evidence of chondrosis. The use of this information in planning trochlear and/or tubercle surgery is beyond the scope of this technique article. Nevertheless, it is worth reemphasizing that patellofemoral problems often are multifactorial, and the debate as to whether the MPFL reconstruction can address all problems of patellar instability, or if it should be combined with tubercle surgery or tubercle surgery should be performed alone, is ongoing and long-term prospective studies are needed to elucidate this issue.

**Examination Under Anesthesia and Arthroscopy**

In addition to documenting the MPFL patholaxity during standard physical examination, the examination is reevaluated under anesthesia. Without the limitations of patient apprehension, further lateral patellar displacement under anesthesia often is observed compared to the examination in which the patient is awake. Arthroscopy allows inspection for possible cartilage lesions, as they are commonly associated with recurrent patellar instability as reported by Nomura and Inoue. If cartilage lesions are present, they are staged by documenting grade and dimension on a patellofemoral region map of the International Cartilage Repair Society (available at www.Cartilage.org). The decision algorithm to treat patellar chondral lesions is outside the scope of this article, but is discussed in detail by Farr in a patellofemoral monograph. Briefly, small lesions may be debrided to avoid intermediate term desquamation, whereas more extensive lesions may suggest the need for cartilage restoration. At the time of cartilage restoration decision, MPFL surgery may still be performed or it may be postponed based on the arthroscopy and conducted later at the time of a concomitant cartilage restoration procedure to minimize surgical trauma. By using all of the data obtained from the physical examination, examination under anesthesia, and arthroscopy, the final decision is made in regards to MPFL surgery.

**GRAFT SELECTION**

The authors’ preferred graft for this procedure is a doubled semitendinosus autograft or allograft. The authors have a slight preference for the use of a semitendinosus allograft rather than autograft to avoid graft site morbidity (pain and any flexor weakness). The disadvantages of using an allograft are longer incorporation time and the potential for disease transmission. The authors, however, have found that these allografts performed similar to the autograft tissue in this richly vascular extra-articular environment. In summary, the use of either allograft or autograft is dependent on surgeon and patient preference. The doubled semitendinosus graft offers a wide “margin.
of safety” in terms of strength. In fact, the purpose of a doubled graft is to match the attachment site area at the patella and not for strength. The strength-to-failure of an intact MPFL is 208 N, with a stiffness of 12 N/mm. The stiffness of a reconstructed MPFL is approximately 12 N/mm, which is approximately 20% of the average stiffness recorded for looped 30-mm long semitendinosus grafts. The strength-to-failure of a double strand semitendinosus is 2330 N, with a stiffness of 469 N/mm. The strength-to-failure of a double strand gracilis is 1550 N, with a stiffness of 336 N/mm. With any of the graft choices discussed above (single or double stranded), the stiffness and strength requirements of the native MPFL are satisfied with a large margin of safety.

If autograft is used, it is harvested through a separate small incision over the pes group tibial insertion after examination under anesthesia and arthroscopy have confirmed the need for MPFL reconstruction. Alternatively, this procedure can also be performed with two tendons, particularly for smaller patients. When autograft is preferred and a hamstring allograft is not available, a tibialis or other foot/ankle flexor tendon may be used, noting in the case of the tibialis, it often will need to be trimmed to a narrower width for proper fit. For the doubled graft technique, the graft is first doubled upon itself. A running baseball stitch (using #2 Fiberwire) for a distance of 25 mm is performed at each free end and the doubled end, creating a Y-shaped graft (Figure 1). The graft tendon is sized at the doubled end for the femoral attachment socket fit (for a single strand, the larger diameter end is sized).

**SURGICAL APPROACH**

For isolated reconstruction of the MPFL (without arthroscopy or associated procedures), two incisions are made over the respective attachment sites—a 3- to 4-cm longitudinal incision along the proximal medial border of the superior one half of the patella and a smaller longitudinal incision over the femoral attachment site in the saddle area between the medial epicondyle and the adductor tubercle (Figure 2). Alternatively, one longer medial patellar incision can be used to expose both sites, particularly when an arthroscopy is necessary such as with cartilage restoration of the patellofemoral compartment.

In general, a lateral release is not routinely performed with MPFL reconstruction, but rather on a case-by-case basis. In fact, be aware that in patients with pre-existing adequate soft-tissue laxity of the lateral retinaculum, a lateral release could create medial subluxation. If the tubercle malalignment is only mildly to moderately abnormal (the TT-TG distance is in the gray area between normal and abnormal) and questions arise regarding the extent or need for tubercle surgery, the MPFL reconstruction can be initiated, but using only pins at the attachment sites and suture to duplicate the planned MPFL. At that point, the potential effect of tubercle surgery can be reassessed. If distal realignment is believed necessary to centralize the patella, it can be performed and fixed followed by completion of the MPFL reconstruction with fine-tuning of the MPFL lengths with this new patellar tracking position.

The patellar area incision is made first. Dissection is performed along the proximal two-thirds of the medial patella to the interval between layer 2 and 3 (between the MPFL and capsular layer). This interval is bluntly developed medially towards the medial epicondyle, using a curved Kelly clamp. The graft should always be placed extra-articular (superficial) to the capsule. A 2-cm femoral incision is made over the tip of the clamp when it overlies the saddle between the epicondyle and adductor tubercle.

The femoral attachment of the MPFL is identified using the landmarks of the medial epicondyle, medial collateral ligament, and adductor tubercle. The femoral attachment of the MPFL resides posteriorly in the “saddle” between the adductor tubercle and medial epicondyle. The fascia is incised and a 2.4-mm guide pin (Bio-Tenodesis Fixation Set, Arthrex, Naples, Fla) is placed just proximal to the epicondyle and distal and posterior to the adductor tubercle. A #2 suture is wrapped around this guide pin and pulled to the patella with the clamp through the same MPFL/capsular interval tunnel and sutured or clamped into the patellar attachment site of the MPFL (which is along the proximal two-thirds of the medial patella, noting the arms of the suture are at the proximal and distal
extent of the patellar MPFL attachment footprint). The suture is pulled so that it is not loose or tensioned with the knee at approximately 30° of flexion. This adheres to the concept of setting the length of the MPFL at the region where the distance between the patellar and femoral attachments are furthest apart (the ligament length could be considered the "longest" at this arc of motion). Although this is conceptually different from using "tension" to determine the graft position/length, the goal of optimally placing the graft to function properly without capturing the patella is shared by both approaches. The knee is then placed through a range of motion. The suture should become lax with increasing flexion and minimally change or slightly tighten in terminal extension (Figures 3 and 4). The planned attachment sites and MPFL length should not over-constrain, tension, or tilt the patella medially at any point during full range of motion. Again, the goal is to create a passive checkrein only.

The femoral origin is much more sensitive than the patellar attachment in terms of achieving an anatomicometric graft placement (ie, the femoral attachment site alters the attachment site distances through range of motion more than the patellar site, as a result of the "cam" shape of the medial femoral condyle. This femoral sensitivity of graft attachment site is somewhat analogous to the femoral attachment site importance in an anterior cruciate ligament [ACL] reconstruction relative to the tibial attachment site). Slight variations in position of the femoral attachment site can have major implications on the patellar tracking and contact forces.12 If the suture does not exhibit the desired length changes during range of motion, the patellar attachment may remain constant while the pin at the femur is repositioned. If excessive tightening occurs in extension, the graft is too distal or posterior, and if there is increased tension in flexion, the femoral point is too proximal or anterior. The most common error is over-constraining, thus causing abnormal contact forces on the medial facet of the patella, as well as making it more difficult to regain flexion in the postoperative rehabilitation. After an anatomicometric position is established, tenodesis at the femoral attachment site is the next step.

**FEMORAL SOCKET PREPARATION**

The doubled femoral end of the graft has been sutured and sized. With the femoral guide pin still in place, a cannulated drill bit 0.5-mm larger than the graft size is chosen from the biotenodesis system. The Table provides a guide for details of socket preparation and screw selection.

The femoral socket is drilled to a depth 2 mm longer than the designated screw size length (Figure 5).

The appropriately sized Bio-Tenodesis screw (Table) is loaded onto the Bio-Tenodesis driver (Arthrex). A #2 Fiberwire suture loop or #2 Fiberwire suture snare is passed through the center cannulation of the driver tip. The sutures extending from the graft are placed through the suture loop. The loop is tightened around the tip of the graft (and knots of the graft suture) and secured as they exit the Tenodesis Driver Handle. The graft is inserted into the base of the femoral pilot hole with the screw on the posterior aspect of the socket and the tendon exiting anteriorly (Figure 6).
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TABLE

GUIDE FOR BIO-TENODESIS GRAFT FIXATION: RECOMMENDED GRAFT, SOCKET, AND SCREW SIZE FOR MPFL RECONSTRUCTION

<table>
<thead>
<tr>
<th>Graft Diameter (mm)</th>
<th>Socket Diameter (mm)</th>
<th>Socket Depth (mm)</th>
<th>Bio-Tenodesis Screw Size (mm)</th>
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Adjustments can be made to place the tendon in different aspects of the tunnel (with respect to the screw) to adjust anatomometric characteristics of graft length, if necessary. The Bio-Tenodesis screw is advanced adjacent to the graft until the screw is flush to the cortical bone rim. Security of the graft is tested. The sutures exiting the Bio-Tenodesis screw and graft sutures may be either tied together to lock the screw and graft together or cut as per surgeon preference.

GRAFT LENGTH SELECTION AND PATELLAR FIXATION

Option A: Bio-Suture Tak “Reverse Loop” Technique

Two doubly loaded Arthrex 3.0-mm (smaller patellae) or 3.7-mm (larger patellae) Bio-Suture Tak anchors are reloaded with the Fiberwire loop end rerouted through the suture anchor loop (Figures 7 and 8A). Alternatively, one 3.7-mm anchor can be used for a single strand graft. The suture anchors are placed in a cancellous trough (created with a 4-mm round burr) in the medial edge of the patella (superior two-thirds) anterior to the articular cartilage (Figure 8B).

The two free arms of the allograft tendon are routed in the developed soft-tissue tunnel interval from the femoral attachment to the patella (Figure 9).

The sutures of the graft double tail ends are passed into the loops, which have been threaded through the suture anchor loops. After pulling the sutures and graft tails through the soft-tissue tunnel, the graft tails are pulled through the suture loops. One tail of the “Y” graft is pulled through the mid-waist loop and the other graft tail through the proximal loop. The suture loops are temporarily cinched tight around the graft and held with hemostats. This initial graft length trial is set at approximately 30° of flexion with both grafts pulled to length with minimal tension and no laxity. The knee flexion position for the first estimation of the graft length is based on a review of biomechanical studies, which together suggest that the attachment site distance (femoral to patellar) is longest near 30° of flexion. (Once again, this emphasis on graft length is analogous to ACL graft “fixation,” as length of the graft determined by knee flexion angle is more important than initial tension on the graft, ie, the major influence of ACL graft function is proper position and length of the graft set at a specific degree of arc of motion rather than tension at fixation.) As during the anatomometric testing with sutures, the applied graft “tension” is primarily to remove “slack” in the graft to assure the length is correct: the object is to select the proper baseline graft length, not a baseline graft tension (Figure 10).

With this “longest length” of the graft (range of motion at which the femoral and patellar attachment sites are furthest apart) selected at a specific range of motion (probably somewhat different from knee to knee, but near 30°), the site of the graft in the suture loop is marked with a marking pen. The knee is placed through full range of motion.
The purpose of this range of motion test is: 1) to assure a smoothly and centrally tracking patella, and 2) that the longest graft length was selected during the anatomometric position analysis. If the graft becomes tensioned (patellar/femoral distance is increasing) with flexion, the mark on the graft will change in respect to the loop. If the graft does not move in the loop, the femoral site was selected properly. Minor adjustments can be made in the length of the graft (through the loop) after checking medial/lateral translation. Optimum graft placement allows the patella to balance in the trochlea or 2+ medial/2+ lateral trochlear quadrants of displacement (or symmetrical) with the other knee, if unaffected. Once the appropriate graft length is achieved, the loops are tied and the graft is folded back onto itself and sutured (Figures 11 and 12).

**Figure 8.** Suture anchor embedded in bony trough, which has been refitted with looped Fiberwire [A]. Medial border of the patella trough created with a burr [B].

**Figure 9.** Passage of the graft to the patella after femoral fixation.

**Figure 10.** With this cinch loop technique, fine adjustments of graft length are possible independent of attachment site selection.

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**Option B: Tendonesis in Patellar Tunnel**

This method of fixation is ideally suited for single strand grafts. Using the patellar poles as a reference, the 2.4-mm guide pin is placed at the junction of the proximal third and distal two-thirds of the patella. The Bio-Tendonesis fixation will be placed on the distal part of the socket, in the wider portion of the patella.

The pin is advanced transversely across the patella until it just exits laterally to ensure placement parallel with the dorsal surface. Anatomometric characteristics should be checked again by placing a temporary suture through...
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Figure 11. After tying the anchor suture loops, additional sutures can be added, further securing the graft to the soft-tissue sleeve at the medial edge of the patella, and the remaining graft can be passed back towards the femoral attachment and sutured to itself.

the graft at the patellar border under appropriate tension. A suture is placed through the dorsal patellar soft tissues at the edge of the socket and the same tensioning check is performed as described before, securing the suture temporarily through the graft and holding it with a hemostat. Once determined, the graft is marked at this point (Figure 13).

The graft is cut 17 mm distal to this point. This portion of the graft up to the mark should be sized and trimmed as well as tapered slightly to between 5 and 6 mm, taking into account that the baseball suture will slightly bulk up the graft. A graft larger than this would require too large a socket and screw for patellar fixation. A baseball suture is placed in this 17-mm free end of the graft and sized once more. An acorn reamer 0.5-mm larger than the graft size is chosen as per the same guidelines in the Table and a 17-mm socket is created (Figure 14).

The appropriate sized screw, most commonly the 5.5×15 mm or the 6.25×15 mm, is placed on the appropriate driver (Table). The graft is pulled up to the tip of the driver with a suture loop through the cannulation of the driver.

The knee is placed in 30° of flexion as the Bio-Tenodesis screw is inserted on the inferior portion of the graft until flush with the cortical rim of the patella. The graft sits superiorly and the screw is in the thicker portion of the patella. Additional backup fixation is possible with a 3.0-mm Bio-Suture Tak placed next to the socket, but this usually is unnecessary. Soft-tissue sutures through the graft and patella can also be used (Figure 15).

Figure 12. The completed reconstruction using suture anchors. (Reprinted with permission from Arthrex, Naples, Fla.)

Figure 13. The guide pin has been placed, and a temporary suture placed at the edge of the patella is used to determine tension. The corresponding location on the graft is marked and the graft is measured and cut 17 mm distal to this point.

The soft tissues of layer 2 can then be reapproximated over the graft and imbricated if necessary. The remaining wound is closed in standard fashion (Figure 16).

POSTOPERATIVE MANAGEMENT

Postoperative Weeks 1-6

A compressive soft dressing and range of motion brace, initially locked in extension, are applied. The brace is opened to allow full extension to 30° of flexion as muscle control is reestablished. Quadriceps isometrics are allowed, unless the surgeon has elected to perform vastus medialis obliquus advancement. Early motion is important to prevent excessive scarring. Because the graft is placed in an “anatomometric” fashion, there should not be excessive graft tension with range of motion as the graft be-
comes more lax with flexion past 20°-30°. An optional continuous passive motion machine may be used in the postoperative period.

During ambulation, the use of crutches and a knee brace in extension are recommended until the patient has good quadriceps control without lag. Weight bearing as tolerated is allowed. Crutches are gradually weaned and discontinued when operative extremity control is excellent and no limping occurs. Standard patellofemoral proximal and core functional muscular exercises are performed throughout the postoperative period. Close monitoring of motion is essential to assure full range of motion is achieved in the early postoperative setting, as this procedure can initiate a vigorous scar response. If articular cartilage procedures are performed concomitantly, progression of exercises, range of motion, and weight bearing are modified accordingly.

**After Postoperative Week 6**

Progressive strengthening and functional exercises are continued postoperatively until full strength, endurance, and agility have been reestablished. Once all goals are met, activities are advanced through a functional progression program. Patellofemoral bracing may be used per patient and surgeon preference.

**DISCUSSION**

Although recurrent patellar instability is a relatively common occurrence after acute patellar subluxation or dislocation, a review of the literature indicates a wide variation in reported recurrence rates. A common theme among authors is the need for a thorough examination and rational patient-specific plan. Although numerous studies exist in the literature detailing the success of nonoperative and operative treatments of first-time patellar dislocations, comparison of these studies is problematic given their retrospective design, small sample sizes, different follow-up times, and heterogeneous sample composition. In an analysis of studies and treatment of acute patellar dislocations by Geary and Schepsis, the recurrence rate after conservative treatment of acute traumatic first patellar dislocations was between 15% and 44%. Likewise, an analysis of recurrence after an acute surgery indicated a recurrence rate between 7% and 33%. Most of these studies are retrospective in nature. Recently, however, one prospective study by Fithian et al indicated a recurrent rate of 49% in patients treated conservatively and 17% in patients with early surgery. They also found that older females had a higher risk of recurrent patellar instability. Multiple risk factors have been associated with patellar instability including tubercle malalignment secondary to either increased femoral anteverision or external tibial torsion, trochlear dysplasia, patella alta, vastus medialis obliquus atrophy, insufficiency of the MPFL, patellar hypermobil-
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ity, and increased patellar tilt with tight lateral retinaculum. With greater patellofemoral dysplasia, the forces required to dislocate the patella decrease substantially.21

Multiple studies agree that the MPFL is the primary static restraint to lateral displacement of the patella.4,6,10 An MPFL tear is the "essential lesion" after acute traumatic patellar dislocation.2,4 In patients with recurrent lateral patellar instability, by definition the MPFL must be attenuated, torn, or insufficient. Although >100 operations exist to treat patellofemoral instability, it now appears essential to address the core lesion. Multiple proximal procedures have been described to treat the MPFL pathology.5,7,9,20,22,23 These procedures include arthroscopic and open approaches, reeling, and some non-anatomic tethering grafts. Those procedures, which are not anatomic, may create abnormal tracking patterns and abnormal contact forces on the patella. Therefore, an attempt has been made to restore a portion of the normal anatomy without over-constraint. Reconstruction of the MPFL is indicated in patients with recurrent lateral patellar instability due to excessive laxity of the medial soft-tissue patellar stabilizers. Medial patellofemoral ligament laxity must be documented by history, physical examination, and in some cases, with imaging and stress radiography. Examination under anesthesia and arthroscopy routinely precede the reconstruction, not only to document the laxity, but also to document tracking patterns as well as to stage and treat associated articular cartilage lesions (osteochondral fracture and/or longitudinal cracks).

The current procedure represents an incremental modification of the multiple procedures described to reconstruct the MPFL.4,11,17 Most of these procedures are performed with a free tendon hamstring graft, which is significantly stronger than the native MPFL. It is suggested that an "anatomometric" approach may be valuable, as an option to an "isometric" approach (choosing the length of the graft, rather than tension). With any approach, careful review of the relevant biomechanics of the MPFL is a critical aspect of reconstruction so as not to over-constrain the patellofemoral joint, particularly the medial facet. In light of the cam shape of the femur, the MPFL is most sensitive to the femoral attachment site. Therefore, it is critical to pick the appropriate points of attachment and test the anatomometric behavior to plan the final fixation points for the procedure. Elias et al.12 have shown that a 4-mm proximal shift in the femoral attachment point of the reconstructed MPFL significantly increases the compressive forces on the medial facet of the patella, as well as increasing medial patellar tilt. In the same study, they also showed that increasing the tension excessively by a length change of as little as 4 mm in the graft also overloads the medial patellofemoral cartilage.

A common problem is placement of the femoral origin too proximally near the adductor tubercle, such that the graft tightens in flexion, leading to markedly increased compressive forces on the medial patellofemoral cartilage in flexion and difficulties in regaining range of motion. Because the MPFL primarily functions from 0°-30°, it would follow that maximum resistance to abnormal lateral tension be in this range. Likewise, it is critical that the ligament reconstruction should act not as a tether, but only as a "checkrein" to prevent excessive lateral displacement of the patella. Normal physiological glide should be re-established at the end of the procedure. The currently described technique allows a reproducible method, not only to examine the anatomometric measurements of the MPFL, but also to fine-tune the graft lengths to reestablish normal physiological patellar tracking.

Pullout strength studies of the fixation used demonstrate that the fixation of the grafts is more than adequate to allow for immediate range of motion after these procedures are performed.1 With secure fixation at both attachment sites and a strong graft tissue, an aggressive early rehabilitation program is not only allowable and safe, but also essential to decrease scarring and muscular dehabilitation.

As mentioned previously in the technique section, in some cases it may be necessary to combine MPFL reconstruction with distal realignment. If distal realignment is believed necessary to centralize the patella, the osteotomy should be performed first and tracking reassessed, followed by completion of the MPFL reconstruction with fine-tuning of the MPFL lengths with this new patellar tracking and position. The goal of the MPFL is to provide a checkrein, stopping laterally abnormal displacement, and is not used to "pull" the patella into the trochlea. In general, distal tubercle transfer combined with the MPFL reconstruction is reserved for those patients with a markedly abnormal lateral tubercle position associated with moderate to severe insufficiency of the medial restraints of the patella. The question of when to perform a distal versus proximal realignment and when they should be combined is a controversial topic, beyond the scope of this article. The important point is to "fine-tune" each procedure when they are combined, particularly in the sense that fine-tuning the MPFL reconstruction should be performed after the distal tubercle transfer. The postoperative radiographs of patients with preoperative static patellar subluxation will vary, depending on whether distal or proximal realignment was performed. On a low-flexion axial view (eg, Merchant radiograph), the patella will remain statically subluxed when treated by those surgeons whose philosophy is to treat only the MPFL and not the tubercle. On the other hand, for surgeons who treat increased TT-TG distances with tubercle medialization, postoperative radiographs may show a more centralized, static Merchant view.
CONCLUSION

Regardless of the means of addressing MPFL patello- laxity, the goal is to duplicate the MPFL anatomy and biomechanics. Although the precise anatomometric characteristics of the MPFL graft have not been universally agreed on in the literature, within the range of reported MPFL characteristics, the currently described technique is reproducible in restoring “near normal” MPFL attachment site positions. This allows the reestablishment of patellar stability without creating abnormal tracking, which is paramount as the MPFL serves as a “checkrein” against laterally directed displacement forces and should not over-constrain the patellofemoral compartment. The adherence to attachment site anatomy and graft length selection allows correction of the pathophysiology of lateral patellar instability and an aggressive rehabilitation program.

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